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PLANT BREEDING IN RELATION TO AMERICAN POMOLOGY.

This bulletin briefly epitomizes the history of plant breeding as applied to the development of American fruits. The subjects discussed are: Beginnings of systematic breeding; the development of American pomology; results of breeding; unsolved problems.

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PLANT BREEDING IN ITS RELATION TO AMERICAN POMOLOGY.

W. M. Munson.

The whole question of plant and animal breeding is in a state of transition, for, with a sudden interest in Mendel's work, and the generalizations of De Vries and others, investigations in breeding are taking a new direction, not necessarily less practical in final results, but at present less comprehensible to the average man. It has therefore seemed worth while to give a brief statement of methods heretofore employed in plant breeding, in their relation to the development of American fruits, and a summary of the results already accomplished.

The breeding of plants, as of animals, is quite as much a question of culture, care and selection, as it is the production of a departure from a given type. Most plants live an indifferent existence, dependent very closely upon immediate conditions of environment. Furthermore, every part of a plant lives largely for itself and is capable of propagating and multiplying itself if removed from the parent plant. This fact increases the importance of suitable environment, and of a knowledge of methods of propagation on the part of one who is to undertake systematic breeding. In the study of plant breeding then, for all practical purposes, the unit is the embryo individual plant, whether in the form of a seed or a bud. While in the light of recent investigations this statement may be regarded as somewhat antiquated, the writer would still maintain the position that in the prosecution of the practical improvement of the American fruits, this proposition will hold. Of course in the scientific investigation of the principles of plant breeding, embryological conditions are of importance.

In recent times the student of plant breeding thinks that he has a key to the laws of plant variation in the so-called "Mendel's Law," and there are many facts which tend to strengthen

that belief, but a discussion of that subject is not intended at this time.

Beginning of Systematic Breeding of Fruits.

One of the most significant facts in nature is that every species of plant which man has cultivated for any length of time has numerous forms, varieties, or strains. The practical horticulturist selects that form or strain which is best for certain purposes or for certain conditions. The plant breeder asks why or how these forms came about and how they can be improved. It is worthy of note, however, that until about a century ago the principal studies of plant life were made from wild forms rather than from domesticated species.

THE WORK OF VAN MONS.

The man who first propounded a theory of the philosophy of the origin of varieties of cultivated plants, was Jean Baptiste Van Mons, who was born in Brussels, in 1765, and died in 1842. Van Mons was by profession a chemist, and horticulture was his avocation. His theory applied particularly to fruit trees, but he held that the principles he set forth are of general application in the vegetable kingdom.

Van Mons' theory may be briefly epitomized as follows: All fine fruits are artificial products. There is always a tendency in all varieties of fruit trees to return, by their seeds, towards a wild state. This tendency is most strongly shown in the seeds borne by old fruit trees. On the other hand, the seeds of a young fruit tree of a good sort, being itself in a state of amelioration, have the least tendency to retrograde, and are most likely to produce improved sorts. Finally, there is a limit to perfection in fruits. When this point is reached, as in the finest varieties, the next generation will more probably produce poorer fruits than if reared from seeds of an indifferent variety in the course of amelioration.

This system or theory was not founded upon experience or practice, but was a preconceived idea of the author, who spent fifty years, with all the zeal of an enthusiast, in an attempt to prove his theory. He began his work by gathering seeds from a young seedling tree without paying much attention to its quality except that it must be in a state of variation. The seed-

lings were planted closely in nursery rows and often checked by pruning, with the thought that to improve the fruit the original rank growth of the tree must be subdued or enfeebled. From the first fruits produced, and the fruit was always gathered before it was fully ripened, seeds were saved and sown again; and this practice was continued generation after generation. The whole process was, to use his own words: "To sow, to re-sow, to sow again, to sow perpetually; in short to do nothing but sow is the practice to be pursued and which cannot be departed from." Van Mons' work, which was largely confined to pears, was begun in 1785. Thirty years later, in 1823, when he had commenced distributing scions freely throughout the world, he had 80,000 seedling trees in his nursery. At this time his first catalogue was issued and in it 1050 pears are mentioned by name or number. Of this list 405 were his own creation and 200 of them had been considered worthy of naming, among them being some of the varieties which are still raised the world over, including Diel, Bosc, Colmar, Manning's Elizabeth, and many others of equal merit. Many of these varieties found their way into America, chiefly through the efforts of Robert Manning of Massachusetts.

Whatever may be thought as to his theories, there is no doubt that Van Mons accomplished more than any other single individual up to the middle of the nineteenth century in breeding new and valuable fruits. Without discussing the principles for the establishment of which Van Mons was working, it is enough to say that in some of his series the generations came into bearing earlier and earlier until in the fifth generations of certain pears, he was able to secure fruit at 3 years from seed. As already intimated, however, this was at least partly brought about by the system of enfeebling and consequent encouragement of the habits of precocity, and by cumulative selection. Probably no worker with plants has ever given to the world so clear a demonstration of the value of selection as Van Mons; and this demonstration is worth all of the efforts put forth, even though this was made in the attempt to prove another and, as is now believed, erroneous doctrine.

WORK OF THOMAS ANDREW KNIGHT.

Contemporaneous with Van Mons, was Thomas Andrew Knight, often referred to as the father of modern horticulture; a man whose work as a careful, accurate, scientific investigator of the phenomena of plant life, especially in its economic relations, is unrivaled even at the present time, and whose opinions upon the studies of crossing and of plant development were of the utmost importance. Knight was born in England in 1759 and died in 1838. His investigations of problems in physiological botany have become classic and he brought the same energy and thoroughness to his investigations of horticultural problems. He gave particular attention to the physiology and methods of crossing plants and was the first to perfect the method of root grafting,* but his greatest work was in the direction of the improvement of cultivated plants, by breeding. He took up the question of the running out of varieties and made great efforts to produce new ones. He was confronted by the same problems which appealed to Van Mons, but he approached the subject in a very different way. Knight asked direct questions of nature, and never arrived at a general theory of the improvement of plants, although he was not without hypotheses concerning the phenomena he was studying.

Van Mons, as noted, was the first to demonstrate the importance of selection in the improvement of plants; Knight was the first to show the value of crossing for the same purpose. As early as 1806 he wrote: "New varieties of species of fruit will generally be better obtained by introducing the farina of one variety of fruit into the blossoms of another, than by propagating any from a single kind." † The varieties which he raised, largely by means of crossing, included apples, pears, plums, peaches, cherries and strawberries, as well as many vegetables such as potatoes, peas, cabbages and others; but more important than the new fruits, which were of immediate and so-called practical value, was the contribution to the general knowledge of plant life, and of the methods to be employed in amelioration, which Knight gave freely for the benefit of all mankind.

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* See Transactions of London Horticultural Society.

† Ibid. Vol. 1, p. 38, 1806.

Such, in brief, are the beginnings of the science of plant breeding, as exemplified in the amelioration of domesticated fruits. Early in the nineteenth century the more advanced horticulturists were awakening to the fact that plants as well as animals are capable of improvement by systematic breeding. As the years have gone on, knowledge of the factors involved, and of methods of procedure, has increased, with the result that a new horticulture has developed in this country. European varieties and European methods of culture have been superseded by varieties and methods of American origin,—varieties and methods better suited to the very different climatic conditions and to popular demands.

The Development of American Pomology.

The records of early attempts at fruit growing in America are mostly records of failure. The varieties first grown were naturally those brought from Europe, and though in the beginning of the last century American seedlings were beginning to attract attention, still the chief effort to extend the range of culture was by the introduction of new varieties from Europe. This was the only way known of securing new sorts.* In 1830, in a letter to Gen. Dearborn, William Kenrick says: "From among 150 varieties imported into Boston by Eben Preble about 1805, the only additions to desirable kinds were two cherries, the Black Tartarian and the White Tartarian, and a single pear." † If fruit culture in this country were limited to the varieties which have come from Europe, it would be of very small proportions. At the present time, while agents of the Government are scouring the world for new species and varieties, plant introduction is very largely looked upon merely as a means to an end. Russian, Chinese and Japanese fruits are being freely introduced, not merely for their intrinsic merit, and in the hope that they may thrive in their new environment, but with the idea that from hybrids between them and the native species, and from American grown seedlings of these imported species, valuable sorts may be obtained.

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* An interesting study in this connection is that of the development of the native grape.—See Bailey, Evolution of our Native Fruits.

† Manning, History of Massachusetts Horticultural Society, p. 42.

CHANCE SEEDLINGS.

In the development of American pomology the first step was a sort of crude selection of chance seedlings, wherever these might be found. The importance of having varieties adapted to existing conditions was early understood, but the question of how to get them was the trying one. It is a notable fact that many of the varieties which today stand out as landmarks, were accidental seedlings or chance discoveries of valuable wild forms.

Among the more prominent American fruit originating in this way may be mentioned the Alexander or Cape grape, which first introduced successful grape culture into Eastern America; the Catawba, still a popular grape; the Dorchester and Lawton blackberries; Seckel pear; Wealthy apple; and many of the best raspberries, gooseberries, cranberries and plums.

SELECTION.

The next step in the improvement of fruits was the selection of parents from which to grow seedlings. The importance of the work Van Mons was doing in Belgium, in emphasizing the principle of selection, has been noted above, but American horticulturists soon outstripped their teacher. In 1882 James Thatcher, in his American Orchardist, made recommendations which today would be regarded as much better than those of Van Mons. He says: "The seeds for planting should always be selected from the most highly cultivated fruit and the fairest and ripest specimens of such variety." William Kenrick, a nurseryman of Roxbury, Mass., was more conservative and inclined to adopt the theory of the natural deterioration of varieties,* at the same time giving in detail the methods practiced by the great European plant breeder, as already described.

A few examples of fruit originating from seed of carefully selected parents will suffice. Diana, early recognized as a valuable child of Catawba; Moore's Early, Worden, Pocklington and the other numerous progeny of Concord, among grapes; Shiawassee, Princess Louise and McIntosh, as seedlings of the Fameuse apple, as well as the numerous offspring of Oldenburg, Rhode Island Greening and others; the seedlings

* Kenrick's New American Orchardist, pp. 24-32.

of Green Gage plum; the Tartarian cherries; and the Crawford peaches are familiar cases in point. But of the immense number of seedlings produced in this rather haphazard way, very few have been found of superior merit. Improvement by selection, in the strictest sense, has been employed most successfully with annual plants, and the methods used have been gradually perfected. In the choice of the foundation stock, however, the same principles are involved in breeding fruits as in the production of choice wheat, corn or cotton, namely: Select parents from stock grown in a locality likely to produce vigorous, hardy plants, and choose individuals of special merit in some particular direction. In the improvement of grapes, many failures have resulted from the choice of tender varieties as parents, although the quality of fruit was greatly improved. In the work of adapting fruits to different climatic conditions of the states west of Lake Michigan, little real progress was made until the introduction of Russian and other so-called ironclad varieties as parent stock. The seedlings from varieties grown in Western Europe or Eastern America were entirely unsuited to the new conditions.

Having the stock from a suitable locality, it is of the highest importance that the individual parent from which seedlings are to be raised shall be the very best of its kind. In working for size in fruit, it is not enough that a plant shall produce one or two abnormally large specimens, but that plants producing a large number of uniformly large specimens should be chosen. In other words, the parent plant should possess in the highest degree the qualities of the ideal form sought, a principle directly contrary to that originally taught by the apostle of selection.

CROSSING.

Cross-fertilization and hybridization were little used in the improvement of plants during the first half of the last century. Knight had shown what might be done, and he had many followers in this country, but the opinion of Van Mons, strengthened by the indisputable array of choice fruits he had obtained as a result of selection, was almost equally strong. In 1836 A. J. Downing wrote: "Assuming Professor Van Mons to be strictly correct, we would suggest that a great saving of time,

and a considerable improvement in quality and vigor, might be gained by calling in cross-fertilization to the aid of the cultivator as soon as the fruit of the trees (say the second generation) begins to show symptoms of amelioration. By impregnating them with pollen of the finest varieties we conceive that the next generation would produce excellent fruit and at a saving of twenty or thirty years." *

In 1844 C. M. Hovey, one of the most successful of the earlier plant breeders, definitely championed the cause of cross-fertilization on the ground that "the results will be obtained in a shorter period and, we believe, equally as favorable as by the method of successive generations alone." Mr. Hovey spoke from experience, his first cross-bred strawberry seedling having been brought to notice in 1838. The striking successes of Hovey, Allen, Downing, and others, soon led to the general adoption of cross-fertilization as a method in the improvement of fruits, and for the last half century the advance has been in the minor factors and not in a better understanding of principles. Up to the present time the question of dominant and recessive characters, as developed in the offspring of crosses, has had very little bearing upon the status of American pomology.

The early hybridizers often used a mixture of pollen, believing that it was possible for the same seed to be influenced by pollen from two different sources, and the possibility of superfœtation was often discussed. The Duchess grape is a result of one of these mixed crosses. This was produced by Caywood "by crossing a White Concord seedling with Delaware or Walter, the pollen of both being applied at the same time." *

One breeder of grapes claimed to produce his new varieties by a new and very simple process, namely by diluting the pollen of the male flower with rain water and then applying it to the pistils of the variety selected as the female parent.†

As a knowledge of the process of fecundation became more clear, other methods of securing desired combinations were adopted and compound hybrids or derivative hybrids became common. Some of the best results have been obtained by such combinations; for example the Brighton grape, which is a

* Bushberg Catalogue, 3rd edition, p. 94.

† Ibid, p. 118.

cross between Diana-Hamburg and a seedling of Concord. The method of using what Webber has called "dilute hybrids" has also been employed with success, particularly in the fixation of types.

THE LIMITS OF CROSSING.

"Crossing is useful as a means of originating new forms adapted to man's special uses and also as a means of revitalizing the offspring by providing new combinations of characters which may better enable the individual to compete in the struggle for existence; but there are limits beyond which crossing is useful neither to the species nor to man." ‡

Without discussing this subject at length, it may be said that, within certain limits, the wider the divergence of the parents in any fertile cross, the more vigorous the progeny. This statement rests on the broad basis of fact, and is corroborated by the work of Darwin and others down to the present day. Nature has comparatively few varieties, the initial variation being usually crowded out in the fierce struggle for existence; but among cultivated plants instead of struggle for existence and the survival of the strongest, we have a struggle for improvement and a "survival of the most coveted." Weeds are best fitted to survive, but the hoe and the cultivator enable the weaker and, for man, the more desirable species to prevail.

So then cultivated plants, leading a life of comparative peace, expend their energies along the lines which are laid down by man. Variations appear and are carefully watched, guarded, and propagated; with the result that in time a new type or variety is produced. But the conditions are vastly more variable than are those under which their wild allies are growing. This leads to a wide range of characteristics found in the same variety, consequently unions are here more powerful than in the wild state, and the expert plant breeder is he who manipulates these forces and their combinations to the best advantage. In the past history of plant breeding this manipulation has necessarily been carried on more or less blindly, but the work of Mendel, DeVries and others seems to open wonderful possibilities in this direction.

‡ Bailey, Philosophy of Crossing Plants.

THE INFLUENCE OF SOIL.

One of the most commonly recognized factors in environment is that of soil conditions. It has been observed by tomato growers, and is commonly taught, that more fruit is obtained on relatively poor soil than on rich.* It should be borne in mind, however, that this increased fruitfulness—at least in the case of the tomato—is relative rather than absolute; that while the proportion of vine is greater on rich soil, the actual amount of fruit is also much greater, and the individual fruits are larger and fairer.†

With this supposition in view, some have thought to produce fruitful varieties by a process of selection and the transmission of the characters of fruitfulness thus acquired. Certain of the small fruits are known to flourish on particular soils or under definite conditions and nowhere else. Particularly is this true of the strawberry, the raspberry and some grapes.

THE USE OF UNRIPE SEED.

As a means of checking too vigorous growth and increasing fruitfulness, the method of using immature seed has been employed with a certain measure of success. It has been found that the use of immature seed increases the productive parts at the expense of the vegetative and thus it comes about that more fruit is formed in proportion to the foliage than is normal. In a series of experiments conducted through several generations by Goff and Arthur, ‡ it was found that a tomato plant selected as a representative of the series grown from unripe seed bore 3½ pounds of fruit to one pound of vine (leaves, stems and roots taken together); while a plant of the same variety grown each year under the same conditions but always from ripe seed gave only 1⅛ pounds of fruit for every pound of vine. We have here then an enormous relative increase of fruitage from unripe seed which in fact "was quite apparent to the casual observer upon looking at the plants of the two series as they grew in the garden, although it required the scales to disclose how surpris-

* Allen, American Garden, Vol. 11, p. 358, 1890.

† Cornell Experiment Station, Bul. 10, 1889; also Ibid., Bul. 21, 1890.

‡ American Naturalist, Vol. 29, p. 905, 1895; also Rpt. Wis. Expt. Station, 8, pp. 152-9, 1891.

ingly great the difference was." * It may be well to note also that, associated with the increase in the amount of fruit, there was also an increase in the number of individual fruits, although these, as also the seed, were individually smaller. Van Mons also employed this method of using unripe seeds in his experiments with apples and pears, for the purpose of checking too vigorous growth and increasing the relative fruitfulness of the product.

Besides increasing the number of fruits, the use of unripe seed also results in early maturity. In the cumulative trials of tomatoes, already mentioned, the strain from immature seed ripened from 10 days to 4 weeks earlier, in different years, than did the corresponding series from ripe seed. Such differences in earliness do not always occur, however, and some observers have noted opposite results; but with the earlier production and the increased percentage of fruit comes also the lowering of vitality and consequent lessened ability to stand unfavorable conditions. In other words, the use of unripe seed is simply a means of checking growth and the usual result follows. Within certain limits checking growth tends to increase fruitfulness, no matter how the check is given. Some have contended that the plants would overcome the initial weakening and upon being subjected to favorable conditions would acquire vigorous growth while retaining the more fruitful habit. Of course this is the end desired as a result of this method of treatment, but, so far as the writer is aware, there is nothing to warrant such a supposition. Experience in breeding tomatoes at this Experiment Station indicates that this desired end is not obtained.

BREEDING FROM ASEXUAL PARTS.

The distinction between seedling varieties and bud varieties is one of degree rather than of kind. The different buds on a tree frequently produce offspring possessing quite as distinct individuality as do the different seedlings from the same tree. So the tree should be considered not as an individual but rather as a collection of individuals, the bud being the unit. Now no two buds on a given tree are subjected to precisely the same conditions. All of the buds cannot possibly survive, hence arises

* Arthur, American Naturalist, 29, p. 906.

a constant and intense struggle for existence. Owing to the different conditions of light, air, food, and room for extension, some branches will be large and vigorous, others will be small and weak; some will produce fruit freely, others will be barren. In the same way, no two fruits are ever exactly alike. Some will be large, others small; some roundish, some oblong; some highly colored and of good flavor; others pale and insipid.

This fact of the universality of bud varieties, together with the fact that variations may be perpetuated by asexual means is of the utmost importance in practical horticulture and in the systematic improvement of fruits and vegetables. The practical fruit grower knows that some trees never bear any fruit and that others of the same kind bear abundantly; that some Baldwins and Spys are habitually large, and others habitually small and unsatisfactory, and these observations are borne out by the records of the Station orchard. Upon close examination of the branches of an individual tree, through a series of years, the same phenomena would be found to exist in individual branches. A very good illustration of the case in point is that of a currant plantation cited by Powell.* A plantation of Fay currants containing some 12,000 bushes came directly or indirectly, through cuttings, from 25 selected plants, purchased when the variety was first introduced. The original plants were uniform in size and very productive. In the haste for a large number of plants the new wood was cut from these bushes every fall, and when more bushes were established they in turn were divided into cuttings as often as new wood was made. Little attention was paid to the bearing capacity of the bushes in later generations because of the excellent character of the original stock. As a result of this lack of attention, at the end of 12 years some of the bushes were found to be heavy bearers, others very light bearers and others almost barren. How this came about is readily seen, and the remedy is equally obvious. If a single bud produces a branch which is barren, or nearly so, and that branch happens to be taken as a cutting, naturally a barren bush results. If this bush, before its character is determined, is used for cuttings, the tendency is perpetuated and an ever increasing series of worthless plants is esablished.

* American Garden, 1898, p. 466.

Some of the numerous examples of bud variations in apples, pears and other fruits will suggest themselves. In Virginia, Albemarle Pippin is a familiar example of bud variation from the Yellow Newtown. In Canada the Red Gravenstein appears. In the Northwestern states, King is hardly recognized because of its elongated form. The propagator has only to form a clear idea of the type of Baldwin, Newtown, King, or other fruit which he wishes to attain, then to select from each generation buds from branches which appear most nearly approximating his ideal. If then the differences in the buds of a tree or other fruit plant can be perpetuated by asexual means, as by cuttings, grafting, etc., it is evident that this method can be depended upon for the systematic improvement of existing varieties; and with most of the commonly cultivated fruits such improvement is vastly more important than a wholesale production of new forms.

The improvement of horticultural varieties does not necessarily follow the lines of improvement in the wild state. Nature builds up her types gradually by the selection, in each generation, of individuals best suited to their environment; in other words by a "survival of the fittest," or, as Bailey puts it, a "survival of the unlike." Man, on the other hand, selects the most coveted, and in order to attain his end supplies the environment best suited to the individual, and with the natural result.

While recognizing and emphasizing the importance of the production of seedlings from judicious crossing, it is believed by the writer that the attention to conditions of environment is infinitely more important than the multiplication of forms, in which the element of chance plays so large a part, and that, unfortunately, in many cases, the principles of selection and asexual propagation have in the past been lost sight of.

The slight differences which any careful observer will detect in the common fruits form sufficient basis for the most favorable of systematic breeding. A few examples of fruit originating in this way will suffice. The origin of the Nectarine as a bud variation of the peach is familiar. Even at the present day such variations are not uncommon. Thomas Andrew Knight records the case of a Yellow Magnum Bonum plum producing a branch which bore Red Magnum Bonum.* Powell cites a

* Cf. Darwin, Animals and Plants Under Domestication.

recent case of bud variation in which a tree of Coe's Golden Drop has produced a branch which for several years has borne red fruit. In every way except color both trees and fruit are identical with Golden Drop. In California, in an Isabella vineyard belonging to J. F. Pierce of Santa Clara, several vines sported in 1882. The fruit of these sports was very much sweeter and altogether superior to the parent variety. It shows no tendency to reversion and is now extensively grown in California under the name of Pierce, bringing a higher price than any other of the American types. It is interesting to note, too, that the Pierce is capable of reproducing itself from seed, thus becoming the first of a race of native grapes.* The grape is prone to bud variations and it is not uncommon to see a branch bearing fruit which differs in size, color or flavor from that of the remainder of the plant. The Golden Queen raspberry originated as a sport from Cuthbert, formerly called Queen of the Market, on the grounds of Ezra Stokes of Berlin, N. J., and was introduced to public notice by J. T. Lovett.

The list of bud varieties is a large one, and no doubt thousands of variations which might have been the basis of new and valuable strains have escaped the attention of horticulturists. But it is not alone to the marked variations or sports that the plant breeder will look for foundation stock. In fact the sudden or violent variations are always liable to reversion. Nature's method of evolution, is a very good pattern to follow in developing certain strains to meet human ideals. In the experimental evolution which the horticulturist is practicing, a definite course of action may be predicted. *First,* determine upon the ideal of the improved type desired. *Second,* cultivate and feed to encourage variation. *Third,* select through successive generations buds, that is cuttings or scions, from branches which bear fruit most nearly approaching the ideal.

Organic evolution has taken place by the selection in each generation of those differences which give the survivors a slight advantage in the struggle for existence. Horticultural evolution, or the systematic production of better types of cultivated plants by man, may take place by the selection of individuals (buds) in each generation which most nearly conform to the

* American Garden, 19, 514, 1898.

ideal type; since, as already intimated, the necessity for a struggle for existence has been obviated.

The whole practice of propagating the common fruits, as followed by most of the nurserymen of today, is radically wrong, and tends to deterioration rather than to improvement. Buds are often selected promiscuously from bearing trees, from barren trees, and from nursery stock of unknown character, and as a result a large proportion of the orchards all over the country contain trees which do not pay the interest on the land they occupy. In the horticultural world a stimulus is needed like that which the Babcock test gave to the dairy world. Some resultant weeding would follow and fruit growers would rise in their might and demand greater care in the production of trees.

It is encouraging to note that a few nurserymen are awakening to the situation and are advertising pedigree stock; but while the signs are hopeful, the intelligent orchardist of the future will be an amateur plant breeder; will set his trees of some strong, vigorous stock, and will top work with the variety or strain which is most desirable.

Some Results of Breeding.

In the foregoing notes some of the methods of plant breeding as applied to fruit, and something of the history of the development of the science in this country, have been given. The significance of the work, and some of the results accomplished in the evolution of American fruits, may properly be considered at this time.

At the beginning of the nineteenth century, almost all of the cultivated fruits were of foreign origin. At present fully 90 per cent of the cultivated apples, and nearly as large a proportion of the pears, are of American origin; that is, have originated from American seedlings. Of plums, the American seedlings of European and Japanese species, together with important native types, and hybrids of these with the foreign species, are rapidly assuming prominence. In the cultivation of grapes, raspberries, blackberries and gooseberries, little progress was made until native species were taken up and improved; and the last half century, indeed the last decade, has seen a most marked development in all of these fruits. It is interesting to note, as bearing upon the general advance in the amelioration of fruits,

that many of the now most important fruits were not only unheard of but were not thought of, as cultivated plants, within the memory of those now living. The improvement of native types has in nearly every case been the result of necessity rather than choice.

The introduction of fruits from Russia and from China and Japan, together with the accidental and systematic crosses between these and the native species and older domesticated types, has not only widely extended the range of fruit growing in this country, but has given a new impetus to the study of fruits and to the production of important forms to meet special requirements. The development of a few of these more important types may be profitably considered.

THE STRAWBERRY.

The strawberry has been under cultivation for centuries, but systematic attempts at improvement are of comparatively recent date, extending back a little more than 200 years in Europe and only about half a century in America. The earliest horticultural variety of which there is any account is the Fressant which dates from 1660. Wild species of strawberry are few in number, certainly not more than a dozen, and only a part of these wild forms have ever been brought into cultivation. Nevertheless, so wide has been the variation under cultivation that at the present time there is the anomaly of a fruit, appearing within a little more than a century, which the botanist does not refer to any species. Here then is a remarkable and practical example of experimental evolution. The history of this evolution has been fully worked out by Bailey, and a few brief notes of his investigations are given in this connection.*

The systematic improvement of the strawberry began in England. The first foreign species to reach Europe was *Fragaria virginiana,* the common field species of New England and the whole Atlantic coast. This is recorded in 1624, but does not appear to have varied greatly, and never found favor on the continent. In England, however, it was more highly esteemed, and after a lapse of 2 centuries—in 1824—Barnet writes enthusiastically "This (the old scarlet strawberry) was doubtless an

* Survival of the Unlike; also American Naturalist, 28, 293.

original introduction from North America. It is singular that a kind of so much excellence as to be scarcely surpassed by any of its class, should have been the first known. It continued in cultivation considerably more than half the period of its existence as a garden fruit without any variety having been produced of it, either by seed or by importation from America." * At this time, however, (1824), Barnet described 26 well marked varieties of the species, at least 4 of which seemed to have come directly or indirectly from America, and probably from wild plants. Thus at the opening of the nineteenth century considerable progress had been made in the amelioration of the strawberry by simple and unsystematic selection. The varieties, however, were much alike and gave little promise of the wonderful development which so soon followed.

About 1712 a second American species, *Fragaria Chiloensis,* was taken from Chili to Marseilles by a Captain Frezier. It reached England in 1727. The plant is stout, thick leaved, rather coarse, bearing large, globular, somewhat pointed, late, dark-colored fruit. The flowers are often imperfect and fail to become fertilized. The species met with but little favor and at the time Barnet wrote, a century after its introduction, so little variation had occurred that only 3 varieties which could be referred to this species were known, and one of these was considered identical with the original plant as introduced by Frezier. The plant was also grown to a very limited extent in France, but there seemed little save size of fruit in the parents of this species, and less in its record under cultivation, to commend it to the attention of the horticulturist.

Some 50 years after the introduction of the Chilian strawberry, a third type made its appearance in Europe. No one knew just how or when it came. Because of the pineapple fragrance of its fruit, it was commonly known as the Pine strawberry, and was described and figured as such by Phillip Miller in 1760.† There were many theories as to its origin but none were more probable than that of Duchesne who, in his Natural History of Strawberries, in 1776 ‡ described

* Transactions London Hort. Soc., 6, 152, 1824.

† Gardener's Dictionary.

‡ Histoire Naturel de Frasiers, par M. Duchesne fils.

a pineapple strawberry as *Fragaria ananassa* and argued that it must be a hybrid between the Chilian and the Virginian. Pineapple strawberries were found in France about the same time as in England, and the two, only differing from each other in a slight degree, came to be regarded as variations of the same stock; a type upon which Ehrhart, in 1792, bestowed the name *Fragaria grandiflora.*

What then is the ancestral type of cultivated strawberries? According to Barnet, whose work has been previously mentioned, there were in all 7 groups of cultivated varieties in 1824; but only 4 of these were of the large fruited types. The Pine, being comparatively a new type, included 20 distinct varieties, and among them one which marks an epoch in the annals of strawberry culture in England, namely Keen's Seedling. From Keen's Seedling, first known in London in 1821, most of the modern strawberries have descended.

At the time Keen's Seedling was produced in England, there were no important varieties of American origin and for some reason Keen's Seedling did not thrive in this country. Prince, in 1828,* mentions 30 varieties of strawberries in American gardens, all but one of which were of foreign origin, and even as late as 1837 Hovey wrote, "as yet the plants of nearly all the kinds under cultivation have been introduced from English gardens and are not suited to our climate.† At the time Mr. Hovey made this statement, however, he was at work in a systematic way at the breeding of plants which should meet existing conditions. He selected parents representing distinct ideals and the best adaptation to American conditions. In one series of crosses which he made 4 varieties were used. From these crosses two varieties, Hovey and Boston Pine were obtained.‡ Owing to the loss of some labels it is not quite certain which crosses gave these varieties, but, according to Bailey, Mr. Hovey was always confident that the Hovey was the result of Mulberry crossed by Keen's Seedling, so that the Hovey was a true pine strawberry. Hovey's Seedling was to American strawberry culture what Keen's Seedling was to English, and most

* Treatise on Horticulture, 72.

† Magazine of Horticulture, 3, 246, 1837.

‡ Magazine of Horticulture, 6, 284, 1840.

of our modern varieties have come directly or indirectly from this one source.

The American strawberries then are lineal descendants of the old Pine class, known to botanists as *Fragaria annassa* and *Fragaria grandiflora,* and this type (species?) as conclusively shown by Bailey * is a direct modification of the American species *Fragaria Chiloensis.*

The history of the production of later varieties is simply a repetition of the work started by Hovey;—a history of crossing and selection with reference to certain specified ideals or in many cases of fortuitous variation and chance discovery. It has been thought that a common perfect flowering variety might impress itself upon a pistilate sort, through its pollen, to such an extent as to effect an immediate modification of the quality or character of fruit.† But further study invariably reverses any such conclusion. Much valuable work, however, has been done, and is being done, in the systematic combining of characters of different varieties by crossing and in the "selection of the most coveted." Attempts to modify the habit of strawberry plants by change of environment have not been particularly successful; though some forms, like the Parker Earle, show a strong tendency to curtail the runners, and varieties strongly resistant to fungus attack are numerous.

GRAPE.

The grape has for many years been the object of systematic work by American horticulturists. It is worthy of note, however, that many of the varieties most highly prized at the present day,—including Catawba, Isabella, Vergennes, Herbemont, Norton's Virginia and others—are simply chance seedlings, discovered in the wild, and domesticated by some careful observer. Some of the varieties named have given many seedlings of merit, besides the definitely recorded crosses made in more recent years. Catawba, for instance, has given Diana, Iona and many others; while Concord, which was a chance seedling discovered by Ephriam W. Bull and first sent forth in 1853, is the parent of a large family of valuable sorts including

* Am. Nat., 28, 301.

† Proceedings of the American Pomological Society, 1885, p. 66.

Eaton, Martha, Moore's Early, Pocklington, Worden, and others.

A marked step in the improvement of the grape was made in 1850 when John Fiske Allen of Salem, Mass., crossed the foreign Golden Chaselas with Isabella. The first of these American hybrid grapes, known as Allen's Hybrid, was exhibited before the Massachusetts Horticultural Society September 9, 1854. Though of excellent quality, this grape was so tender and subject to rot that it was never widely planted. It is of importance, however, as one of the parents, with Concord, of that delicious white grape Lady Washington; but its chief significance was the fact that it was the beginning of a new era in the improvement of grapes, namely, the production of seedlings of known parentage by means of systematic crossing.

With a few exceptions, all of the American table grapes are the result of careful selection and breeding since 1850; and a record of the productions since that date is a record of the work of Rogers, Ricketts, Caywood, Jacob Moore, Munson, Campbell and other equally enthusiastic amateurs or practical nurserymen.

There is little difficulty in producing seedling grapes of the finest quality by crossing the best native species with varieties of *Vitis vinifera.* Unfortunately, however, hardiness of vine and vigor of constitution are usually sacrificed. Occasionally a seedling is produced which combines the excellence of the two parents, and here is the first step in improvement. It was along this line that E. S. Rogers of Roxbury, Mass., following the lead of Allen, worked; and many of his hybrids have justly won a place in popular favor. Among these may be named Salem, Agawam, Wilder, Massasoit, Goethe. The greatest weakness of these varieties results from their imperfect blossoms and consequent irregular bunches of fruit. Rogers believed that the line of improvement lay in crossing his hybrid with the foreign species; but, though thus producing fruit of exquisite flavor, the increased tenderness and weakness of the vines rendered these second crosses nearly worthless.

J. H. Ricketts, a bookbinder of Newburg, N. Y., for more than 20 years continued his careful work in the production of crosses and hybrids. His early work, like that of Rogers, was mainly in the effort to produce hybrids with the European grape. Later, however, he undertook the production of derivi-

tive hybrids and crosses among our native species. Some of the results of his work are Empire State, Lady Washington, Eldorado and Jefferson.

Jacob Rommel of Morrison, Mo., holds the place as a leader in the production of wine grapes adapted to the conditions of the Southwest. Among his products may be mentioned Elvira, Amber, Black Delaware and Pearl—all products of crosses with native species, mostly *Vitis riparia* and *Vitis labrusca.*

Jacob Moore of Brighton, N. Y., was the originator of several valuable grapes as well as other fruits. It is enough to mention Brighton and Diamond. The first a cross of Concord and Diana-Hamburg; the other also a secondary cross between Concord and European (Vinifera) stock. (Diamond is a cross between Concord and Iona).

George W. Campbell of Delaware, Ohio, after spending many years working at random, settled on the definite work of improving existing types along certain well defined lines. For example a Catawba without the tough acrid pulp about the seeds; a Delaware of larger size and more vigorous habit, or a Concord of fine flavor and better shipping qualities. His greatest success was in his last mentioned effort, the result being Triumph and Campbell's Early, which are really improved Concord.

Dr. A. T. Wylie of North Carolina should be mentioned because of his attempts to bring into service the native Scuppernong grape in producing hybrids for growing in the far South.

The list of those who have contributed to the number of varieties of grapes suitable for different conditions and localities, varieties of intrinsic merit, is a long one, and it is unnecessary to speak in detail of the work of Caywood, of Barry, of Arnold, of Grant, and some others; but the man who has done the most extensive work in improving the native species of grapes, and extending the list of varieties suitable for the Southern States, is without question Mr. T. V. Munson of Dennison, Texas. The value of his work is not confined to the South alone, however, as those who are familiar with Brilliant and others of his newer varieties are aware. Among the best of the Munson productions are America, Beacon, Captain, Carman, Brilliant, Gold Coin, R. W. Munson. During the past 25

years Mr. Munson has produced 75,000 seedling varieties, including hybrids between the Post-Oak grape of the South and several other native species, as well as combinations of well known varieties and species.

THE PEAR.

The European pear is of particularly fine quality and in recent years has been found to succeed well on the Pacific Coast, but it has never proved wholly satisfactory in the Eastern States and is a total failure in the South. As will be remembered, Flemish Beauty and several of our choicest European varieties are found especially subject to disease, and in the earlier years of American pomological history the failure of the varieties which were general favorites in France and Belgium was attributed to deterioration of the variety itself,—in other words to "running out." William Kenrick wrote of these pears:* "Except in certain sections of the city, and some few solitary and highly favored situations in the country round, they have become either so uncertain in their bearing—so barren—so mortally diseased—that they are no longer to be trusted; they are no longer what they were once with us, and what many of them are still described to be by most foreign writers."

One of the first varieties of native introduction was the Seckel, and to this day it remains the standard of excellence among pears. The origin of this variety is not quite certain, though it is supposed to have been a chance seedling. It first attracted attention in the garden of Mr. Seckel of Philadelphia, who is generally regarded as the originator; but Thomas Andrew Knight believed it to have originated in a Swedish settlement near the city about the middle of the eighteenth century, Mr. Seckel having obtained cions of it from Jacob Weiss, who obtained the original tree from the Swedes.†

Some other well known varieties originated as chance seedlings in the early part of the last century. Among these may be mentioned Tyson, Andrews, Fulton and some others. As the superior value of American seedlings became recognized, the practice of planting the seeds of the best fruits became common. One of the most extensive producers of these seedling varieties

* New American Orchardist (2nd ed.), 25.

† Cf. Trans. Lond. Hort. Soc'y, 3:256, 1819.

was Mr. Dana of Massachusetts, the originator of Dana's Hovey. This sort appeared about 1860, and was the best of his seedlings, of which he had some 5 or 6 thousand.

Among the best known varieties originating in Maine may be mentioned Eastern Belle and Indian Queen, seedlings raised by Henry McLaughlin, Bangor; McLaughlin, sent out by S. L. Goodale of Saco; Goodale, a seedling of McLaughlin; and Fulton, a chance seedling from Topsham.

The development of the cultivated pear owes little to the hand of man in producing hybrids; yet, with the possible exception of Bartlett, the few hybrid varieties produced—notably Kieffer, Le Conte, and Garber—are by far the most important commercial sorts, and have made possible the cultivation of the pear over the greater part of our country. These varieties, as now generally recognized, are accidental hybrids between the European pear and the Chinese sand pear. The latter is a vigorous, healthy tree, of no value save for ornament or as stocks for other sorts, but is native to a region not unlike our own eastern and southern states. The hybrids combine to a large degree the good qualities of both parents, and point the way to new fields of investigation for the plant breeder.

THE APPLE.

As in the case of pears, the Newtown Pippin apple, which is usually regarded as a standard of excellence, originated as a chance seedling, nearly 200 years ago. Because of its better adaptation to the climate, the apple was much more widely grown than the pear, and the production of new varieties from seed was very common. Until very recently, however, the varieties were usually the result of chance. The Baldwin, which was found in Eastern Massachusetts, in 1742, took its name from Col. Baldwin, who first brought it into general notice. The Northern Spy, originating near Rochester, N. Y., about 1800, the Roxbury Russet, the Jonathan, and, in short, most of the older commercial varieties, came about in this way.

Systematic breeding of the apple in this country is yet in its early infancy, though as long ago as the time of Knight and Van Mons crossing and selection were practiced. With the westward march of civilization the necessity of producing

hardier varieties became evident. The struggles and failures and disappointments of Peter M. Gideon in the effort to produce a variety which should withstand the trying climate of Minnesota were finally, after many years and the loss of thousands of seedlings, rewarded by the production of the Wealthy. With the introduction of this variety began a new era in the fruit culture of the northwest—indeed, this was the starting point of successful fruit growing in that region. The introductions of Russian varieties by the Department of Agriculture and by Budd and Gibb, followed by the crosses of these sorts with the hardier commercial varieties and with the native crabs, are recent history. The work of Budd, Harris, Patten, Somerville, Watrous and others in this direction has resulted in a large number of so-called ironclad varieties of very fair quality, many of which will keep until late in the spring. But this work is only begun. A discussion of the varieties originating in Maine will form the subject of an early bulletin from this Station.

THE PLUM.

The production and propagation of named varieties of native plums dates from 1814, when the seed which produced what is now known as the Miner plum was planted by William Dodd, an officer under General Jackson.* The Wild Goose was introduced in 1850, and Robinson in 1884. The latter is of special importance as one of the parents of some of Burbank's recent novelties. Since 1860 the number of valuable seedlings of the native species in the West and South is almost phenomenal. Wayland, Moreman, Golden Beauty, Newman, and others in the Southwest; Wolf, De Soto, Rollingstone, Forest Garden, Weaver and the like in the Northwest, to the number of a hundred or more, are already grown to an important commercial extent, and it is possible that these will form the foundation of the future orchard plums of the Prairie States.

Only recently has any attempt at improvement by artificial crossing been made; and this attempt has been mainly at combining the native species with the newly introduced Japanese sorts. The work began less than 20 years ago, yet, on the authority of Professor Waugh, there are at the present time

* Cf. Bailey, Evolution of our Native Fruits, 175.

more than 30 of these hybrids which have been found valuable and named. Luther Burbank of Santa Rosa, California, is the name which is indelibly associated with the idea of Japanese plum hybrids, and to him we are indebted for Climax, Chalco, Wickson, Golden, American, and many others.

THE BLACKBERRY.

Brief reference should be made to the blackberry as a purely American plant. Though wild plants had been brought to the garden previously, the culture of the blackberry as a garden fruit dates from the introduction of the Dorchester, a chance seedling found in Dorchester, Mass., and brought to attention by Mr. Lovett in 1850. A few crosses have been introduced, but none as yet have become well known. A noteworthy hybrid of the blackberry with the raspberry should, however, receive passing notice. This is the Princess (Western dewberry crossed by Siberian raspberry) produced by Mr. Burbank. The hybrid, according to the originator, ripens its fruit several weeks before either of its parents and excels them much in productiveness and size of fruit, though retaining the general appearance and combined flavors of both. Among other raspberry-blackberry hybrids made by Burbank is Humboldt, by crossing an improved California wild dewberry with Cuthbert raspberry. As giving an idea of the uncertainty of work of this kind, it is worthy of note that the last named hybrid was the only one out of 40,000 seedlings that was deemed of sufficient value for propagation.

Some Unsolved Problems.

Each year marks a great advance in the work done in plant breeding. The work carried on by the United States Department of Agriculture, under the immediate direction of Dr. Webber, is of inestimable value; and the "new creations" in fruits and flowers which periodically appear in the garden of Luther Burbank at Santa Rosa, California, have attracted world wide attention. But the mere production of new forms of intrinsic value is not the only work in hand. It is now coming to be recognized that many diseases of plants are due to some, often times it may be slight, lack of adaptation to conditions and surroundings. The plants are "out of tune" with their

environment, and this lack of adaptation, though slight, may make the difference between profit and loss in the returns from a given crop. The disease known as *couloure,* or the falling of the flowers and young fruit of certain of the finest raisin grapes in California is a case in point. An investigation by officers of the Department of Agriculture has shown that this trouble is mainly due to unfavorable climatic conditions at the time of blooming. If, now, the time of blooming should be delayed somewhat until the season of settled weather, or if the varieties should be rendered slightly hardier, so as to resist the unfavorable conditions, a service of untold benefit would be rendered to the raisin industry of California. In the attempt to meet the emergency, some 20 thousand crosses have been made between the two best raisin grapes—Muscat of Alexandria and Muscatel Gordo Blanco—with the Malaga, a vigorous, hardy, thrifty sort which, though an excellent raisin grape, is inferior to the sorts named.* As the seedlings resulting from these crosses come into fruitage the hardiest and most resistant types will be selected in the hope of securing the desired end.

A similar problem confronts the growers of citrus fruits in Florida and Louisiana,—a fact again emphasized by the recent severe losses from freezing. Here, again, the Department of Agriculture is doing an important work in crossing the more valuable varieties of the orange with the *Citrus trifoliata,* which is hardy as far north as Philadelphia. Several hundred hybrids have been produced and are now growing; many of them showing varieties intermediate in character. Of course the end in view is to secure, by a sufficient number of crosses, a variety which shall combine the good qualities of the common orange with the hardiness of the trifoliate parent. The same method may be looked to in the production of hardier varieties of other subtropical fruits.

Another problem in citrus culture is the production of an orange with the skin of a tangerine. Hybrid seedlings to the number of a thousand or more have been produced, and results are awaited with interest. The breeding of pine-apples of superior quality, and resistant to disease, is also receiving special attention in the subtropical laboratory of the Bureau of Plant Industry, the crosses of this fruit running up into the thousands.

* Yearbook, U. S. Dept. of Agriculture, 1898, 265.

In pear growing it is very important to combine the disease resisting qualities of the Oriental varieties with the highest quality of fruit of the European sorts. Some hundreds of crosses have been made with this in view.

In plum culture, especially in northern New England, the same problem is met. In former years plum growing was an extensive industry in the Penobscot valley, but the dreaded black knot drove the industry out of the country. Is it possible, by crossing with the Japanese varieties, which seem less subject to the attack of this disease, to produce sorts which, while resistant to disease, shall be hardy enough to resist the severe winter?

Cherries also, in years past, have formed an important item in the income of fruit growers along the Kennebec. But the demand for sour cherries in the Boston markets is limited, and the hearts and biggarreaus are very uncertain in point of hardiness. Most of the cherries for which Hallowell and Gardiner have been locally noted in the past, were seedlings of Black Tartarian. But these seedlings are very uncertain and are frequently killed back by severe winters. With a view to combining the vigor and hardiness of the sour cherries with the good qualities of the fruit of the sweet sorts, Card of Rhode Island, has made numerous crosses. A large proportion of the sour cherries crossed by the sweet varieties matured fruit which apparently was normal. Curiously enough, however, the reciprocal crosses in every instance failed to mature fruit;* and in a personal letter to the writer, Professor Card writes that in only two instances was he able to secure germination from the crosses made—and these seedlings met with an accident and were lost.

Apples, quinces, peaches and the various small fruits, are all, without doubt, capable of producing disease resisting forms which shall do away, in a measure at least, with the expense and labor of spraying and otherwise combating the numerous fungous pests with which the orchardist must contend.

While the reigning types of native fruits are the result, largely, of the force of circumstances rather than the direct choice of man, an intelligent choice of species and of forms has, nevertheless, played an important part in the evolution of these types, and it may play a still more important part in the years to come.

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* Rpt. R. I. Expt. Station, 1899, 130.

As suggested at the beginning of this discussion, plant breeding in its relation to pomology has as yet been largely fortuitous. Little study of fundamental laws has been made. Thousands of crosses have been made and hundreds of thousands of seedlings have been produced, but the work has been largely without definite ideals in view, and without a view of probable means of reaching an ideal. In the judgment of the writer, the problems of propagation, environment, and individual variation are of quite as much importance, and are certainly as little understood, as are the obscure problems of cytological variations and combinations.

Many years ago Thomas Andrew Knight popularized the method of root grafting, and the question of the mutual influence of cion and stock has long been a fertile one for discussion. Nevertheless little accurate work has been done in studying the problems thus involved.

It is known, in a general way, that certain chemicals have specific effects upon the color, composition or other characteristics of fruits, but acurate data in this direction are scarce. The fact of individuality in fruit plants is recognized, but its importance as a factor in the development of a type has been almost wholly overlooked.

The fact of the existence of graft hybrids is freely maintained, but the principles involved in the production of such forms remain a closed book.

In the past most discussions of pomological problems have been empirical. There are certain principles underlying the subject, however, which, in common with the improvement of plants in general, are fundamental and far reaching in their importance. It is to this class of problems, more scientific but not less practical in their nature, that pomologists and plant breeders alike are devoting thought and study at the present time. The solution of some of these problems, and the classification of knowledge concerning the subject, is necessary in order to raise pomology to the rank of a distinct science.